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Doctoral thesis abstract

Thesis title: „ Study of supercontinuum stability and spectral width in all-solid photonic crystal fibers with all-normal dispersion”

Supercontinuum generation in photonic crystal fibers has been of interest for scientists for several years. Typical supercontinuum spectrum is generated in anomalous dispersion photonic crystal fibers due to a sequence of nonlinear effects, e.g. soliton generation and fission and so called modulation instability. This effect contributes to significant spectrum broadening, but also causes strong amplification of background noise. For the sake of new applications, spectrally smooth and highly phase coherent spectrum is needed. In normal dispersion photonic crystal fibers solitonic effects does not occur, what allows time-stable supercontinuum generation with good flatness in broad range of spectrum wavelengths. However, the resulting spectrum is usually spectrally much narrower than a spectrum obtained in fiber under anomalous dispersion pumping. The use of all-solid photonic crystal fibers allows broader supercontinuum generation in normal dispersion regime, than observed so far in traditional air-glass photonic crystal fibers. In all-solid photonic crystal fibers chromatic dispersion is shaped not only by the waveguide dispersion of the photonic lattice, but also material dispersion of both thermally matched glasses. This increases the flexibility of the fiber’s chromatic dispersion design process, allowing broader supercontinuum generation by proper dispersion curve shaping.

In this work I investigate the stability and spectral width of supercontinuum spectrum generated in all-normal soft-glass photonic crystal fibers. The work involves photonic crystal fiber designing, modelling of nonlinear effects present during beam propagation, fiber fabrication and characterization, supercontinuum generation measurements and supercontinuum pulse stability analysis. At the beginning, I describe the problem of supercontinuum spectrum stability and its width obtainable in the normal dispersion regime. I present thesis objectives, its claims and motivation for research. Next, I give theoretical introduction to optical fibers, nonlinear optics and supercontinuum generation. Further in the work I present the design method of fiber geometrical lattice and dispersion profile as well as the fiber fabrication method. I also describe differences between all-solid and air-glass photonic crystal fibers. Next, I show numerical results. I discuss limits of flattened part of fiber dispersion profile and I present a method of overcoming those limits. I describe optimization process of fiber chromatic dispersion for broad supercontinuum generation. I also present the dependence of width and flatness of supercontinuum on the parameters and temporal shape of the input pump pulse. Furthermore, I show the influence of temporal pump pulse shape on supercontinuum spectrum generation process and on the shape of the spectrum. Then I show experimental results. I discuss the reference all-solid photonic crystal fiber structure with all-normal dispersion and the results of supercontinuum generation obtained in this structure for various pump pulse conditions. Next, I present results of supercontinuum generation in the all-solid photonic crystal fiber with optimized dispersion for various pump pulse conditions, which was fabricated by me during my research. I analyze

also the coherence properties of shot-to-shot supercontinuum spectrum in normal dispersion regime. I investigate the phase coherence of the spectrum by means of numerical simulations and interferogram measurements. A measure of phase coherence of the spectrum is complex degree of coherence. I measure the intensity stability of the spectrum with the dispersive Fourier method. I analyze the influence of pump pulse temporal shape on the stability of the supercontinuum spectrum with the use of correlation maps. Finally, I finish the thesis with a summary of the results of work, I also present scientific novelties of the work and further possible directions of research in the discussed field.